10. Measuring krill abundance and current vectors using multi-instrumented remotely monitored buoys: submitted by David A. Demer (Leg II), Derek J. Needham (Leg II) and Michael A. Soule (Leg II).

10.1 Objectives: For over a decade, the Antarctic Treaty's Committee for the Conservation of Antarctic Marine Living Resources (CCAMLR) has been pioneering the ecosystem approach to fisheries management. The United States supports this international effort through the Antarctic Marine Living Resources Program (AMLR), managed at SWFSC, which aims to describe the functional relationships between Antarctic krill (*Euphausia superba*), their predators, and key environmental factors. AMLR's annual field studies include shipboard surveys of the meteorology, oceanography, phytoplankton, zooplankton and nekton around the South Shetland archipelago and a predator-monitoring base at Cape Shirreff, Livingston Island, Antarctica. The responses of land-based predators to changes in the availability of their food source are investigated. One challenge of this investigation is to temporally and spatially match the observations of predators and their prey.

10.2 Methods and Accomplishments: Multi-instrumented, remotely monitored, oceanographic buoys were developed to provide long time-series measurements of relative krill abundance in the near-shore area of Cape Shirreff. The Advanced Survey Technologies Program (AST) contracted Derek Needham and associates of Sea Technology Services to fabricate AST's concept for the lightweight, low-cost, spar buoys (Figure 10.1). One of the prototype buoys was fitted with a 300kHz acoustic Doppler current profiler to measure current vectors, acoustical volume backscatter, water temperature, pitch, roll, and bearing. Additionally, the buoys included a data logging computer, GPS, radar reflector, strobe, radio-modem, and power management circuit. Remote control of the instrumentation and real-time monitoring of data was accomplished by radio-telemetry between the buoy and a land-station. A second buoy was fitted with a Simrad ES60 dual-frequency echosounder (38 and 200kHz).

Two buoys were deployed in succession, approximately 5 n.mi. east of Cape Shirreff near the head of a submarine canyon (Figure 10.2). The mooring location was chosen for its consistent association with krill aggregations and predator foraging activities (See near-shore survey section in this report and in the AMLR 1999/00 Field Season Report). At 2200 on Sunday 17 February 2002, the ADCP Buoy was deployed over the stern of *Yuzhmorgeologiya* and towed to the mooring with a zodiac. The buoy appeared stable in the 1m swell. It stood upright, with the 20m tethering bridle preventing the wind from laying it over. There was about 30cm of freeboard on the electronics casing. The waves washed over the top of the electronics casing as predicted in the design; that was a good indication that the buoy was being effectively decoupled from the wave motion. The next morning, communications with the ADCP Buoy were established, from Cape Shirreff base, and a series of tests were performed. ADCP data was downloaded from the previous night and all appeared operational. The ADCP pitch and roll sensor showed movement of less than 10°. It was noted that on about 50% of startups, Windows 2000 read the GPS data as a PS2 serial mouse and took control of the Com port. At these times, the GPS data was not accessible and the mouse cursor made random movements. This problem was remedied with Windows 2000 Service Pack 2. On Saturday 23 February 2002, the ADCP Buoy was retrieved and the ES60 Buoy was deployed from the stern of *Yuzhmorgeologiya*, with assistance from a zodiac. The recovery went smoothly as the zodiac was able to keep the buoy away from the stern of the ship by maintaining tension on a towrope. The ADCP Buoy seemed in good condition and only paint chaffing was noticed around the top tethering point.

The ES60 Buoy was fitted with a Yuasa 12V 7Ah Gel battery and a 110V inverter to overcome unexpected problems of the 12V supply dipping during startup, precluding the echosounder from starting. This also helped to alleviate the problem of the echosounder shutting down at 11.8 VDC opposed to its specification of 11V. Operating with this ad-hoc solution, the ES60 Buoy was attached to the mooring when the ADCP buoy was recovered. The ES60 Buoy had less freeboard than the ADCP Buoy, settling with a waterline about 100mm below the top lid of the electronics case. The ES60 Buoy communicated with the shore station on time, but no GPS fix could be obtained. The ES60 was stopped (power still applied) and the system was left running for 30 minutes to see if the GPS would initialize itself. There seemed to be a problem with the GPS as no fix was obtained. There was power and communication with the GPS. Noise was also noted on the 38kHz trace, possibly from the inverter. At that time, it was also noted that the radio link was sluggish due to the frequent graphics update in the ES60 software. At 0700 on Sunday 10 March 2002 the ES60 Buoy was recovered after being deployed for 15 days. The buoy performed well in approximately 2 to 3m seas.

10.3 Results and Tentative Conclusions: Preliminary results have identified a variable shoreward current in the canyon, possibly causing episodic upwelling of deep water into the neritic zone. The biological scattering observed with the ADCP, possibly from krill, is high when the current is eastward or shoreward (ie. circa 12, 26, and 63hrs), and relatively low during the episode of westward and offshore currents (ie. 34-50hrs; Figure 10.3). Mid-morning each day, a light scattering layer is observed with the ES60 between approximately 5 and 60m (Figure 10.4). Around noon on the third day, the krill appear to descend to the seafloor. At approximately 1600 local time (GMT-3), a dense scattering layer appears between the surface and about 30m. A longer time-series for each of these data types would be very useful to characterize the temporal dynamics of prey behaviors and availability.

A relatively safe and cost-effective method has been developed for routinely and remotely monitoring the prey available to seals and penguins based at Cape Shirreff. The first deployments have garnered new information about the temporal variation in krill dispersion and possible environmental forcing.

10.4 Disposition of Data: Acoustical data from the ADCP and ES60 Buoys are available from David Demer, Advanced Survey Technologies Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, phone/fax: +1 (858) 546-5603/5608; email: David.Demer@noaa.gov.

10.5 Acknowledgements: We are very thankful to Rennie Holt for recognizing the value of a remotely monitored, multi-instrumented buoy array for monitoring oceanographic processes and krill availability in the penguin and seal foraging areas near Cape Shirreff. Moreover, we are thankful to Dr. Holt for funding this year's proof-of-concept endeavor. We are thankful to the Chief of deck operations aboard R/V *Yuzhmorgeologiya*, Oleg Lyaskovski, and to his crew for ably deploying and retrieving the buoys. Thanks also to Adam Jenkins and Rob Rowley for driving the zodiacs for those operations. In addition to Derek Needham from Sea Technology Services, special thanks go to his subcontractor, Mike Patterson, who performed the large majority of the buoy fabrication, in short order, and to Mike Berryman who programmed the buoy control software.

Figure 10.1. Multi-instrumented buoy deployed from R/V *Yuzhmorgeologiya*. The radar reflector, strobe and radio-modem antenna are visible at the top of the buoy's mast.

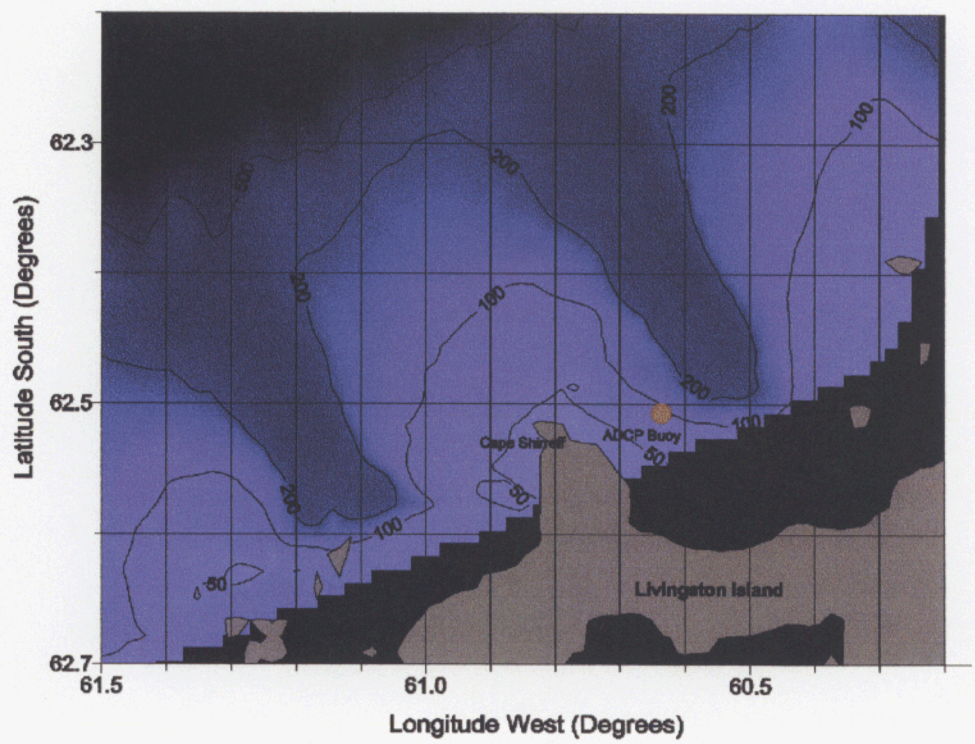

Figure 10.2. Buoy mooring location (red dot). Buoys were placed approximately 4.5 n.mi. to the east of Cape Shirreff field station and near the head of a submarine canyon.

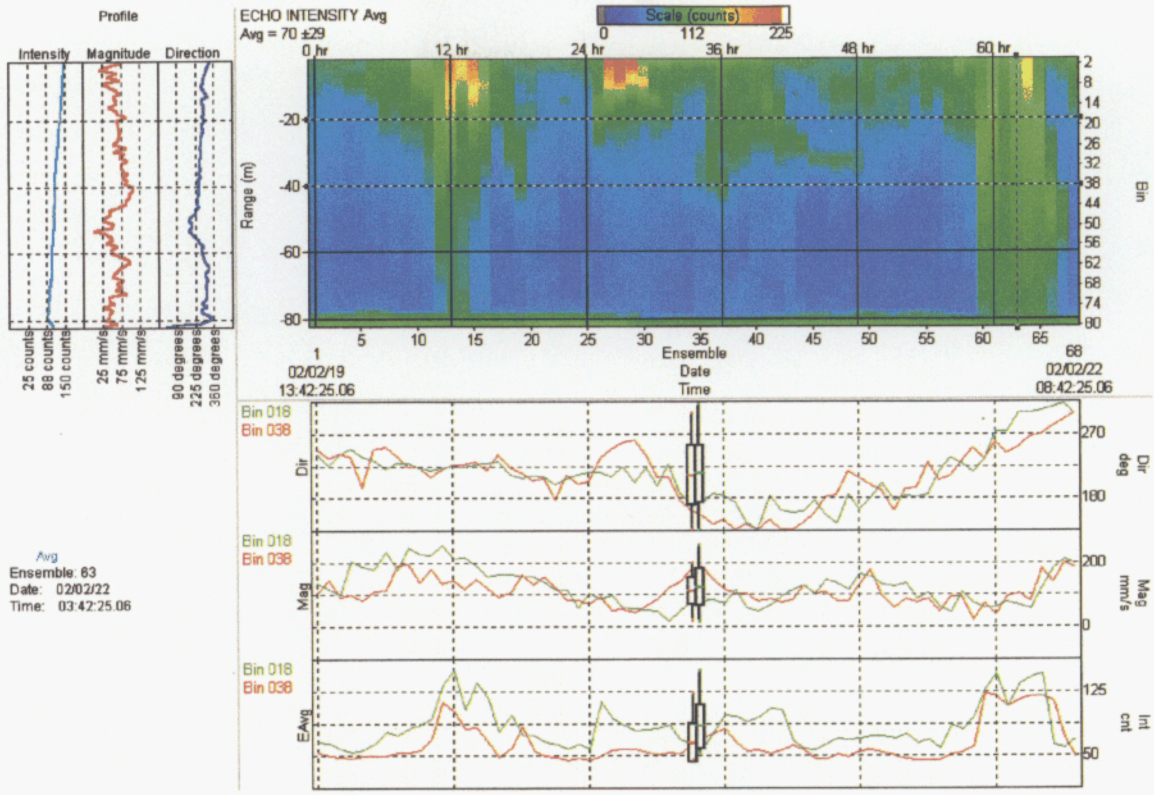

Figure 10.3. Sample profiles of echo-intensity, and current magnitude and direction (top left); echogram for the last three days of the ADCP-buoy deployment (top right); and time series of current direction and magnitude and echo intensity at 20 and 40m depths (bottom right). Note the diel fluctuations in the echo-intensity.

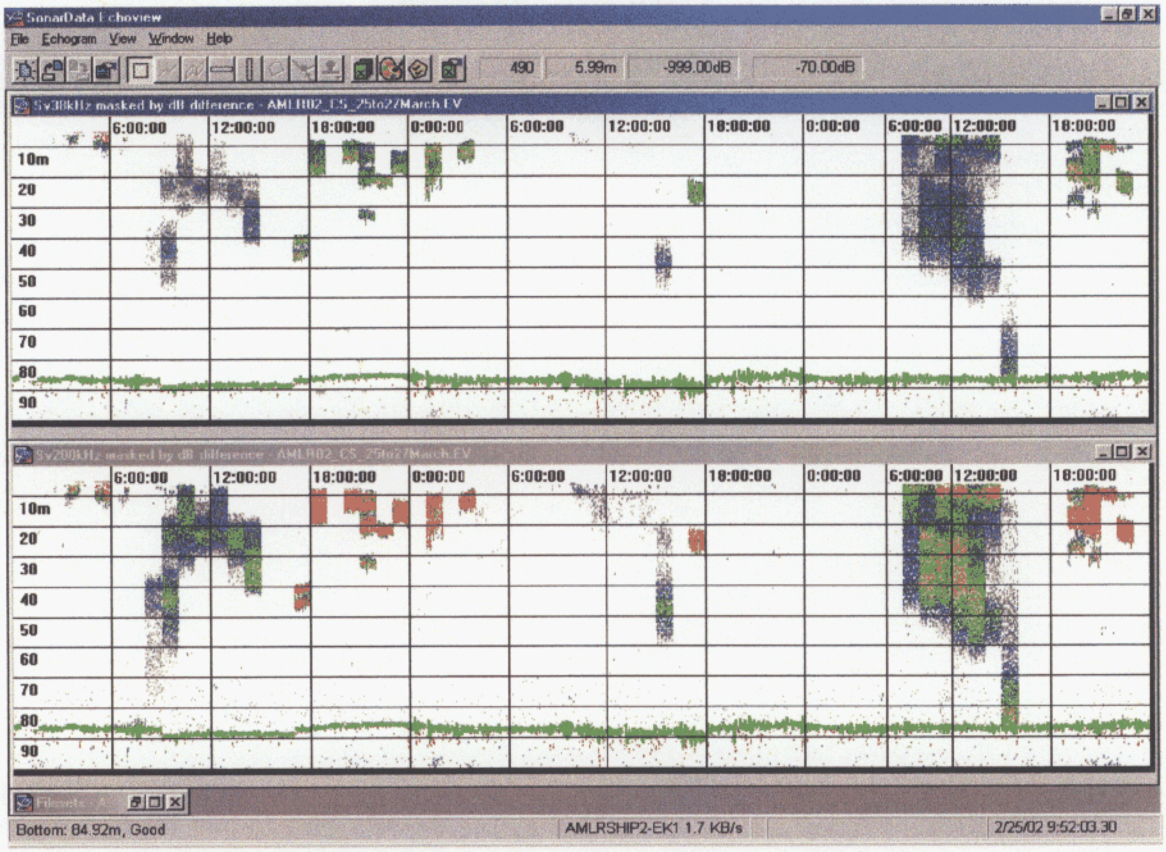

Figure 10.4. Resampled echograms (5 ping averages) from the ES60 echosounder operating at 38 (top) and 200kHz (bottom). The volume backscattering strength data (Sv) are displayed where $Sv_{200kHz} - Sv_{38kHz}$ is between 4 and 20dB. Thus, the scattering believed to be from krill is displayed for the three-day time-series (25-27 March).